

The story of the other side

- Carlota Perez also indicates the sixth cycle:
 - Possibly biotechnology, bioelectronics, nanotechnology, and new materials, as they seem to be in gestation.
 - Transistors were in gestation during 1950s
- More about these waves later
 - Disruptive technologies by Clayton Christensen

Links to System Dynamics. In addition to a shared focus on evolutionary change, an obvious link between system dynamics and radical political economics is the economic long wave, or Kondratiev cycle. The system dynamics national model generates, among other behavior modes, a 40-60-year macroeconomic cycle, or long wave (Forrester 1979). This

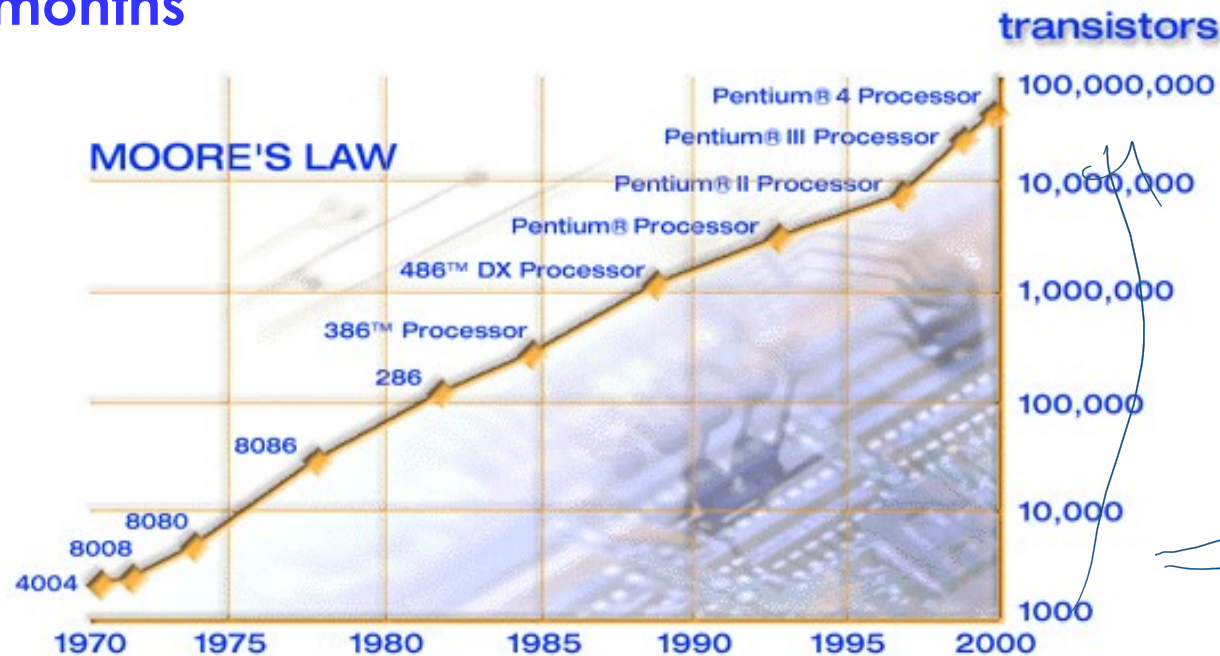
On the vicious circle of disruptive technologies with a flavour of exponentiality

OPIM 302

Moore's Law



In 1965 Gordon Moore, co-founder of Intel predicted that the number of transistors per integrated circuit would double every 18 months



IMPLICATION: Price performance of computing will continue to improve exponentially

Fastest computers

Rank	Rmax Rpeak (Tflops)	Name	Computer Processors	Maker	Site Country, Year
1	478.2 596.4	<i>Blue Gene/L</i>	eServer Blue Gene Solution 212992 (Power)	IBM	Lawrence Livermore National Laboratory United States, 2005
2	167.3 222.8	<i>JUGENE</i>	Blue Gene/P Solution 65536 (Power)	IBM	Jülich Research Centre Germany, 2007
3	126.9 172.0	<i>Encanto</i>	SGI Altix ICE 8200 14336 (Xeon), InfiniBand	SGI	New Mexico Computing Applications Center United States, 2007
4	117.9 170.9	<i>EKA</i>	Cluster Platform 3000 14240 (Xeon), InfiniBand	HP	Computational Research Laboratories India, 2007
5	102.8 146.4		Cluster Platform 3000 13728 (Xeon), InfiniBand	HP	Swedish National Defence Radio Establishment Sweden, 2007
6	102.2 127.5	<i>Red Storm</i>	Cray XT3 26569 (Opteron)	Cray	Sandia National Laboratories United States, 2006
7	101.7 119.4	<i>Jaguar</i>	Cray XT4/XT3 23016 (Opteron)	Cray	Oak Ridge National Laboratory United States, 2006
8	91.3 114.7	<i>BGW</i>	eServer Blue Gene Solution 40960 (Power)	IBM	IBM Thomas J. Watson Research Center United States, 2005
9	85.4 100.5	<i>Franklin</i>	Cray XT4/XT3 19320 (Opteron)	Cray	National Energy Research Scientific Computing Center United States, 2007
10	82.2 103.2	<i>New York Blue</i>	eServer Blue Gene Solution 36864 (Power)	IBM	Stony Brook University/Brookhaven National Laboratory United States, 2007

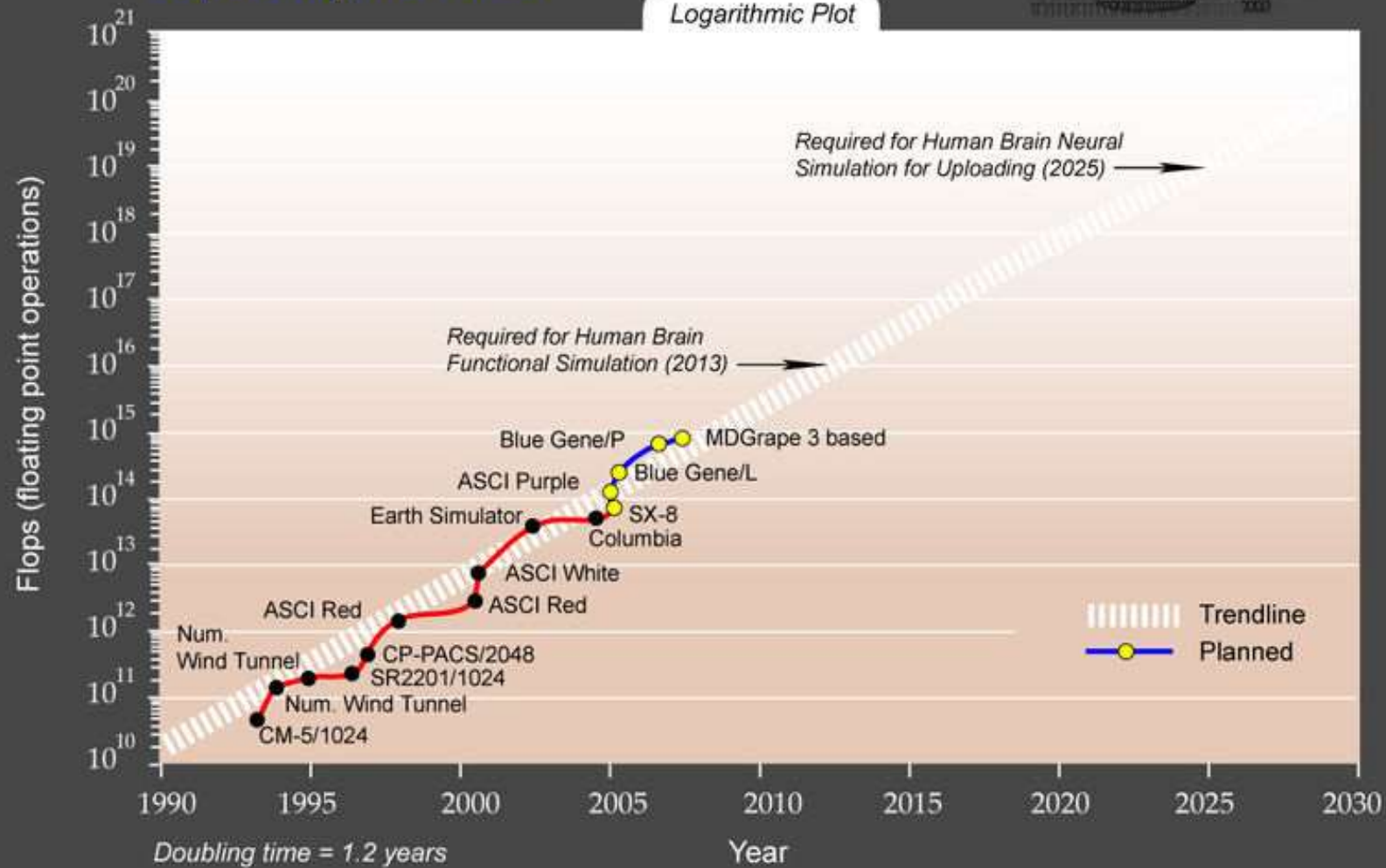
2008	United States	IBM	Roadrunner	1.02 PFLOPS*	[26]
				1.10 PFLOPS*	
2009		Cray	Jaguar	1.75 PFLOPS*	[27]
2010	China	National University of Defense Technology	Tianhe-1A	2.57 PFLOPS*	[28]
2011	Japan	Fujitsu	K computer	10.51 PFLOPS*	[29]
2012	United States	IBM	Sequoia (Blue Gene/Q)	16.32 PFLOPS*	[30]
		Cray	Titan	17.59 PFLOPS*	[31]
2013	China	National University of Defense Technology	Tianhe-2	33.86 PFLOPS*	[32]
2016		NRCPC	Sunway TaihuLight	93.01 PFLOPS*	[33]
2018	United States	IBM	Summit	122.30 PFLOPS*	[34]
2019				148.60 PFLOPS*	[35]
2020	Japan	Fujitsu	Fugaku	415.53 PFLOPS*	[36]
				442.01 PFLOPS*	

• Cost of computing

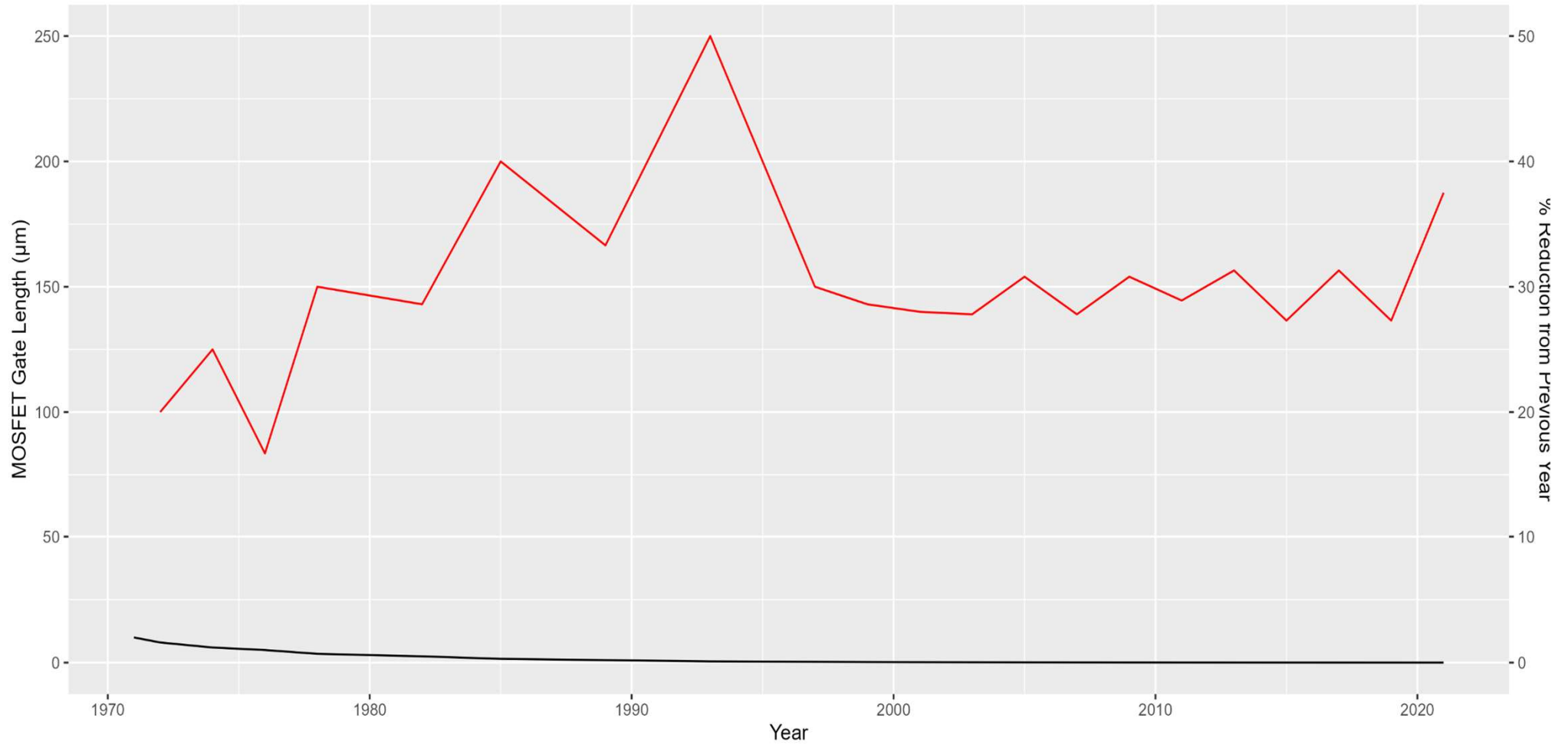
- Hardware costs:
 - 1961: about US\$1,100 per FLOPS; with IBM 1620 @ \$64,000 and a multiplication operation taking 17,700 microsec
 - 1997: about US\$30,000 per GFLOPS; with two 16-Pentium-Pro-processor Beowulf cluster computers
 - 2000, April: \$1,000 per GFLOPS, Bunyip, Australian National University. First sub-US\$1/MFlop. Gordon Bell Prize 2000.
 - 2000, May: \$640 per GFLOPS, KLAT2, University of Kentucky
 - 2003, August: \$82 per GFLOPS, KASY0, University of Kentucky
 - 2006, February: about \$1 per GFLOPS in ATI PC add-in graphics card (X1900 architecture) — these figures are disputed as they refer to highly parallelized GPU power.
 - 2007, March: about \$0.42 per GFLOPS in Ambric AM2045
 - 2015 January : \$0.08 Celeron G1830 R9 295x2 System Built using commercially available parts.

Growth in Supercomputer Power

Logarithmic Plot



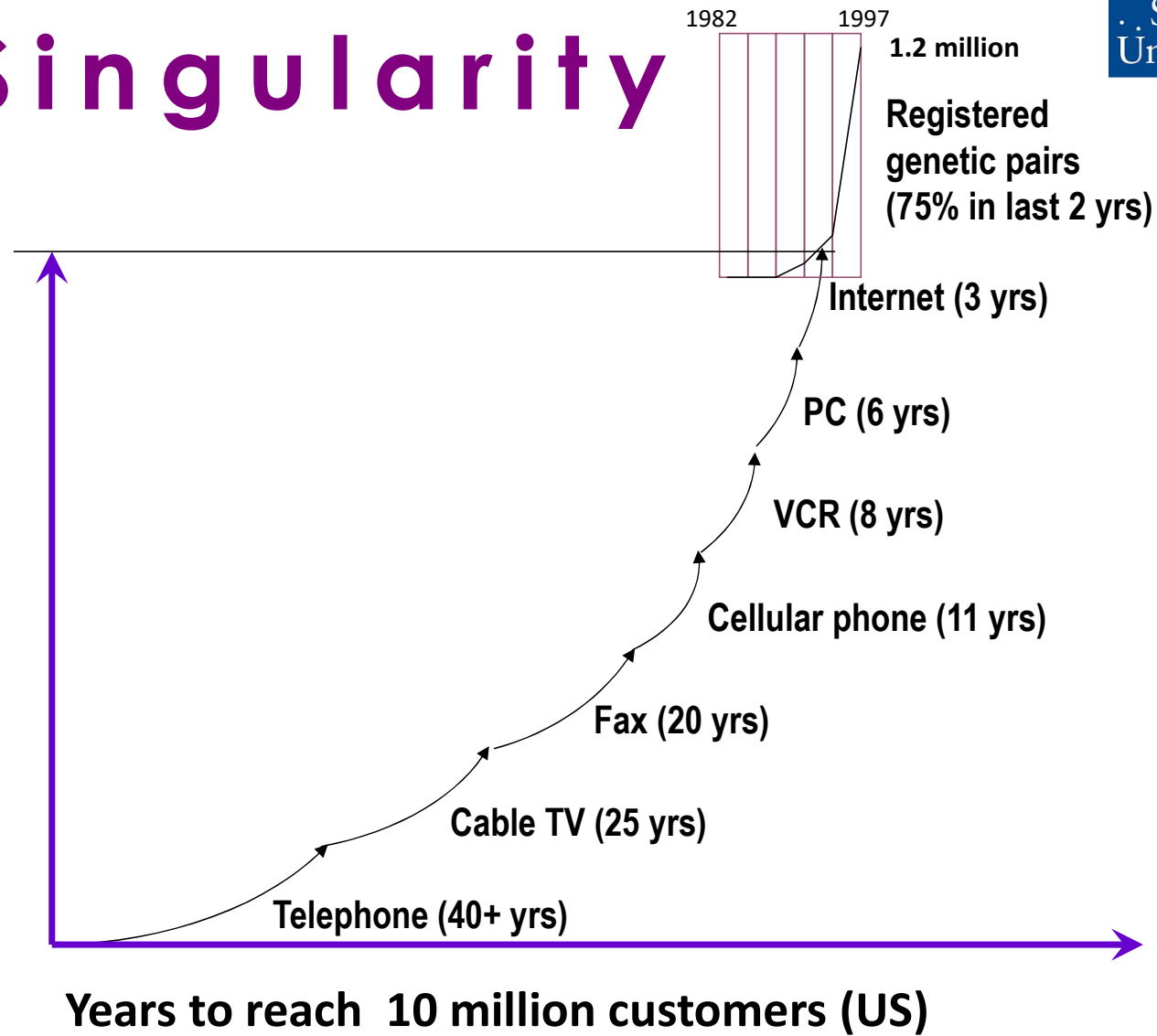
MOSFET Gate Length and Reduction from Previous Year (1971-2021)



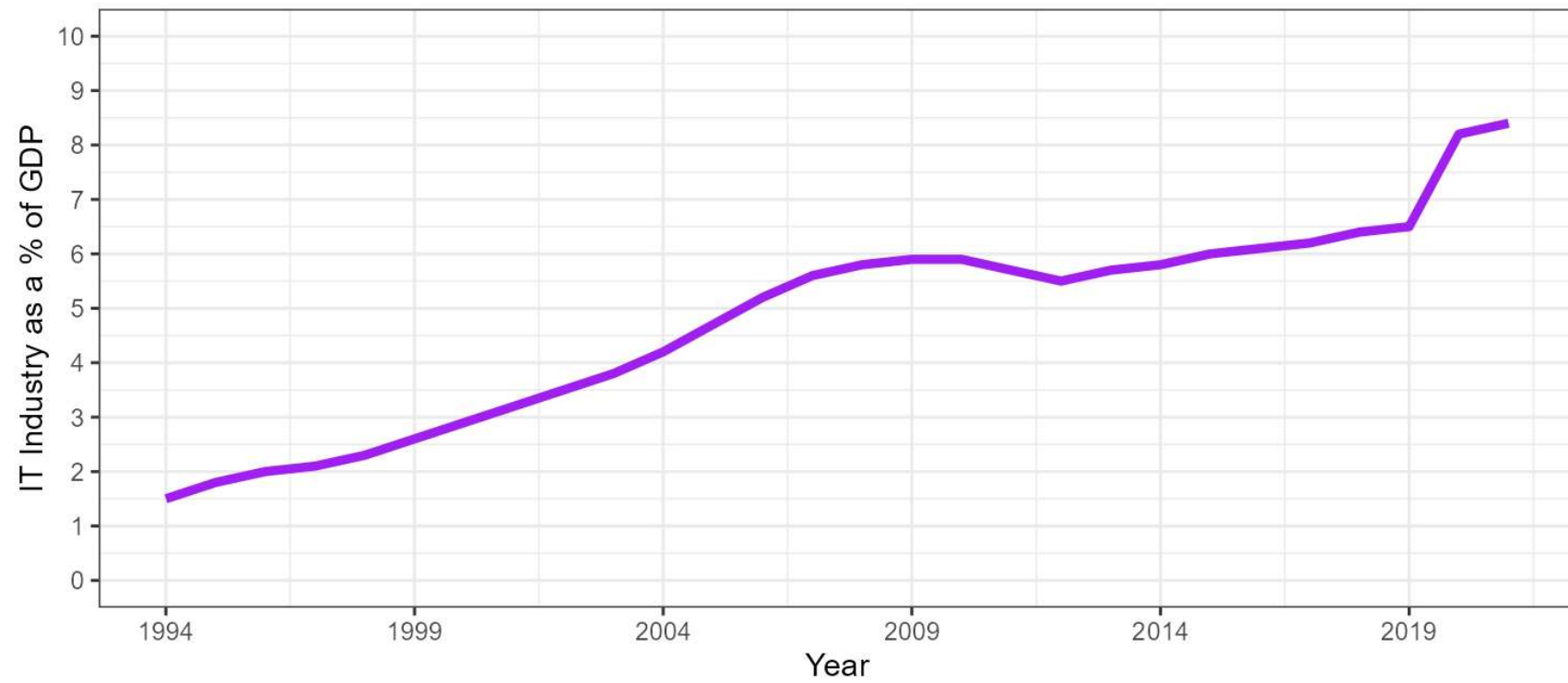
— MOSFET Gate Length — Reduction from Previous Year

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Singularity



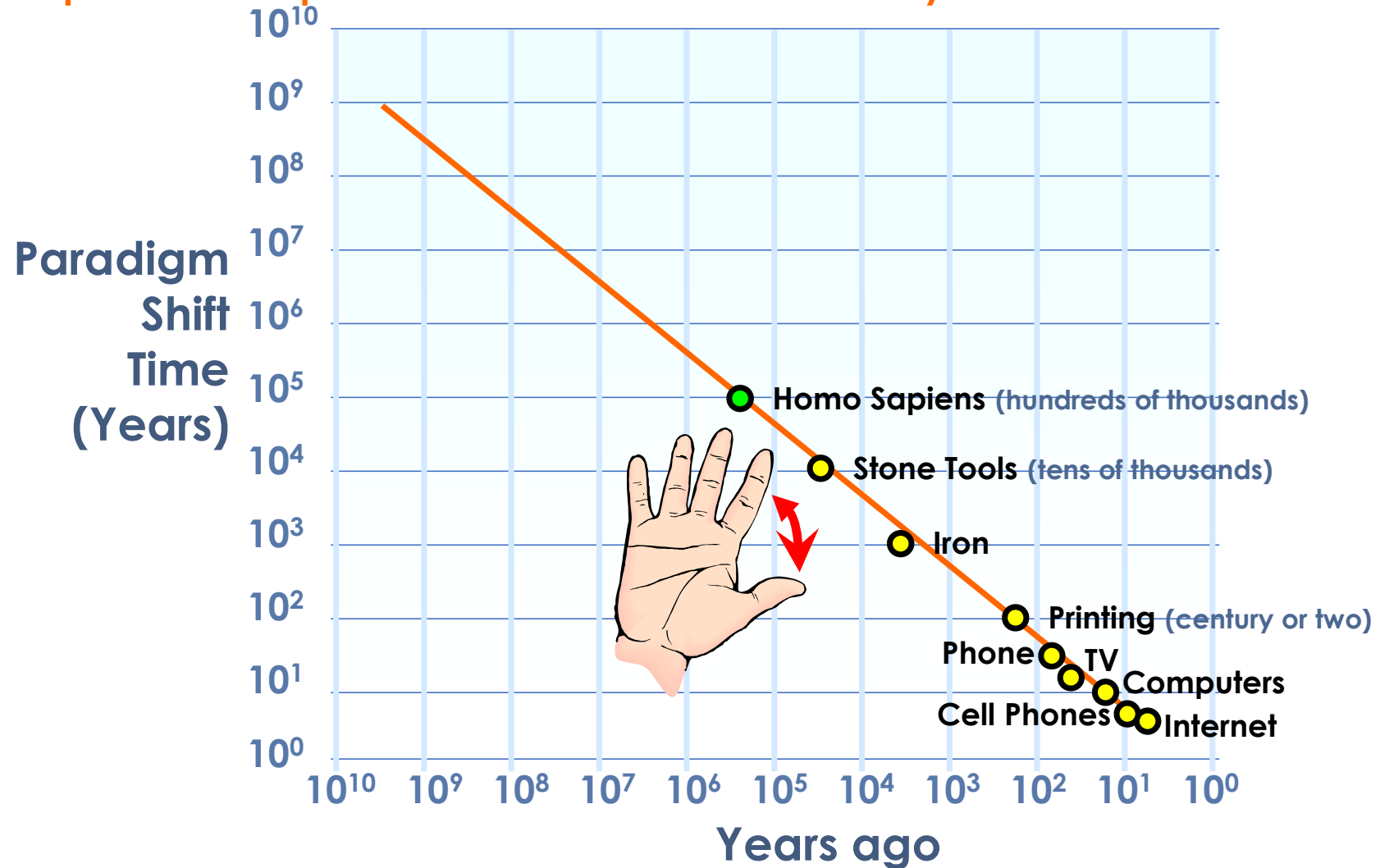
IT Industry's Share of US GDP (1975-2021)



- <https://www.youtube.com/watch?v=Kd17c5m4kdM>

Countdown to singularity

Singularity is technological change so rapid and so profound that it represents a rupture in the fabric of human history



Ray Kurzweil: A Generalized Moore's Law

